Issues in the assessment of nutritional status using anthropometry*

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Four issues in the use and interpretation of anthropometry are discussed at the level of the population and of the individual. The first issue is the index or indices of choice: weight-for-height versus height-for-age versus weight-for-age. The selection of an index or indices depends upon many factors, and no one index is completely adequate in all situations. Proposed criteria are provided to assess the severity of low anthropometry within populations. The second issue is the scale of the index: z-scores (or standard deviations) versus percentiles versus percent-of-median. z-Scores have several properties that make them superior to the other two scales. A third issue deals with limitations in the current growth reference; one of these is the disjunction between the growth curves at 2 years of age, resulting from the use of two different populations in the reference. It is important that this disjunction be recognized by researchers so that the anthropometric findings are interpreted correctly for this age range. Lastly, some issues to do with the collection of single versus multiple anthropometric measurements on children are discussed.

Introduction

Anthropometry is widely used as a tool to estimate the nutritional status of populations and to monitor the growth and health of individuals. The three most frequently used anthropometric indices are weight-for-height, height-for-age, and weight-for-age. In this article we address four issues related to the use of the CDC/WHO International Growth Reference (*1–3*) in anthropometric assessment that are important to the presentation and interpretation of anthropometric information. Specifically, the following issues are considered: the relation between the anthropometric indicators; the scale of the indicators (*z*-score versus percentile versus percent-of-median); limitations in the current growth reference; and single versus multiple measurements. The implications of each of these issues and how they influence the interpretation of anthropometry at both the level of the population and of the individual are emphasized.

Relation between the indices

The relative merit of each of the anthropometric indices used in assessing nutritional status has been discussed previously (*4, 5*) but will be reviewed briefly with emphasis on certain aspects. The two preferred anthropometric indices for nutritional status are weight-for-height and height-for-age, since these discriminate between different physiological and biological processes (*4*). In some situations the concern should be with low weight-for-height (i.e., wasting or thinness), a condition that reflects a failure to gain weight or a loss of weight. One advantage of weight-for-height is that is can be calculated without knowing age, which makes it useful in populations that do not record dates of birth or for whom such information is unavailable or unreliable. In other situations where wasting is not a major problem, low height-for-age (i.e., stunting, short stature, or linear growth retardation) may be of primary concern because a high prevalence of low height-for-age is frequently associated with poor overall economic conditions and/or repeated exposure to adverse conditions (*6, 7*). Weight-for-age is primarily a composite index of both weight-for-height and height-for-age and fails to distinguish tall, thin children from those who are short with adequate weight. The use of weight-for-age for predicting or identifying "wasted" children was found to have a low sensitivity and specificity in three U.S. populations (*8*).

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Considerations at the population level

The anthropometric assessment of a population should assist in identifying groups at risk of poor functional outcomes (morbidity and mortality), and who therefore are in need of further evaluation or intervention. If the prevalence of wasting is high, such as in famines, efforts should be directed towards providing adequate foods and the prevention and treatment of infectious diseases, including diarrhoea and measles (*9, 10*). If the prevalence of stunting is high but the prevalence of wasting is low or close to normal, as is commonly the case in non-emergency conditions, the appropriate prevention or treatment strategy needs to be tailored to the causes of stunting within the population. A high prevalence of stunting is generally associated with low socio-economic status; therefore, efforts aimed at increasing food availability, dietary quality, hygiene, adequate supplies of potable water, and prevention and treatment of infectious diseases should improve the situation within the population over time. The specific causes of stunting and their relative importance may differ from region to region (*11*). Because low birth weight has been associated with short stature and low weight-for-height into early childhood (*12*), activities to alleviate factors that lead to low birth weight, such as inadequate nutrition and the lack of comprehensive antenatal care, should also have an impact on reducing the prevalence of short stature and low weight-for-height in the current population and potentially in future generations by decreasing the prevalence of small maternal size (*4, 5, 13*).

Using data compiled by WHO (*29*), an ecological correlation analysis of 22 African countries has been performed. In these data, the prevalence of low anthropometry (<–2 standard deviations (SD) for weight-for-age, height-for-age, and weight-for-height) was known by 1-year age intervals for children aged less than 5 years. The prevalence of underweight was positively correlated with that of stunting and wasting (for all age groups, $r = 0.61$ and 0.64, respectively, unpublished data). Very little correlation existed between wasting and stunting ($r = 0.1$). Another study using ecological correlations found similar results between wasting and stunting in Africa, but a low correlation within Latin American countries and stronger correlations for Eastern Mediterranean and Asian countries (*14*). However, as with any ecological analyses, these results need to be interpreted cautiously because of the potential for fallacies (*15*).

In populations where the prevalence of underweight among children is high but the prevalences of stunting and wasting are unknown, the nature of the nutritional problem is unclear and should be interpreted within the context of the situation and take into account other health indicators. For example, Table 1 provides examples of countries where populations have similar prevalences of underweight but dissimilar prevalences of stunting and wasting. Intervention activities directed towards these different populations would probably be different because, for example, in Côte d'Ivoire and Ethiopia the activities should first be directed towards resolving the causes of wasting, while in Burundi and Morocco the appropriate intervention should focus on resolving the factors associated with stunting.

Table 1: **Comparison of the prevalence of low anthropometry from different populations[a]**

Country	Year of survey	Age range (months)	% prevalence of: Underweight	Stunting	Wasting
Côte d'Ivoire	1986	12–23.9	19.8	19.8	16.5
Morocco	1987	12–23.9	20.1	31.8	6.4
Ethiopia	1982	24–35.9	40.2	47.7	12.1
Burundi	1987	24–35.9	44.9	60.4	3.5

[a] Low anthropometry defined as <–2 standard deviations of the median of the reference population.

Once an anthropometric study has been completed, the prevalence of low anthropometry should be compared with other populations to assess the severity. Based on the anthropometric assessments performed in many countries around the world, proposed criteria for assessing the severity of these indicators are shown in Table 2.

Considerations at the individual level

As mentioned above, weight-for-age fails to distinguish between short children of adequate body weight and tall, thin children. This arises because the weight-for-age index ignores the child's height, and at a given age, taller children tend to be heavier than their shorter counterparts. This is illustrated in Table 3, which depicts growth data for seven 18-month-old males. Children are considered to be of low anthro-

Table 2: **Proposed epidemiological criteria for assessing severity of undernutrition in populations[a, b]**

Indicator	% prevalence: Low	Medium	High	Very high
Underweight	<10	10.0–19.9	20.0–29.9	≥30.0
Stunting	<20	20.0–29.9	30.0–39.9	≥40.0
Wasting	<5	5.0–9.9	10.0–14.9	≥15.0

[a] Undernutrition defined as <–2 standard deviations of the median of the reference population.
[b] Age <60 months.

pometry if they are <–2 SD of the median of the reference population. The very tall child in example 1 in Table 3 would appear to be relatively normal based on the weight-for-age *z*-score, but "wasted" if a weight-for-height *z*-score is used. This child, who is already "thin", would need to lose 1.7 kg (16% of his body weight) in order to be classified as underweight, whereupon his weight-for-height *z*-score would be –3.7 (see example 2 in Table 3). Examples 3 and 4 in Table 3 depict a similar situation for a moderately tall child, and examples 5–7 for a short child. When a child is underweight, further assessment is necessary to determine whether this is due to wasting, stunting, or a combination, because the treatment, if necessary, should differ. Nevertheless, in many situations, weight-for-age may be useful for following a child over time to identify a downward trend, since this often detects acute changes associated with wasting. It would not be possible to identify whether a slow decline in weight-for-age is due to linear growth retardation, because of gradual inability to maintain their weight-for-height status, or both.

The ecological associations between the different indices at the population level have been discussed previously, but what we really need to know is the association between the anthropometric indicators at the individual level. From additional analyses of survey data from Palestinian refugees (*16*) and from Haiti (*17*), it was found that there was a stronger association between wasting and underweight than between stunting and underweight, and relatively little association between wasting and stunting (unpublished data). There is a need to investigate further these associations in other populations.

Children of all ages who have low weight-for-height or who have experienced growth faltering (in terms of weight-for-height) are likely to respond positively towards intervention or treatment of the cause(s) of their condition. With height-for-age, in many populations appropriate treatment of children under 2 years of age generally results in improved stature, but for older children treatment will most probably have little effect on the child's height-for-age status (*5*).

The usefulness of the different indicators is depicted in Table 4. This can depend upon whether the information is collected for purposes of diagnosing an individual's nutritional problems or for diagnosing those of a population. At the individual level, weight-for-height would be the index of choice if one of the main goals of the health providers is to identify and treat wasted children. Height-for-age is the index of choice when one of the main goals is to identify and treat stunted children.

At the population level, weight-for-height and height-for-age may be useful for identifying subgroups with a high prevalence of wasting (weight-for-height) or stunting (height-for-age) for directing resources to resolve the problems. In some situations the main purpose of calculating height-for-age may be for use at the population level in order to identify subgroups with a high prevalence of stunting or for evaluating the effectiveness of interventions directed towards the population, such as improved water quality and quantity.

In many populations weight-for-age is the only indicator used, primarily because of the simplicity of collecting only one measurement. This indicator is clearly inadequate if age is not accurately known, and rounding of age may introduce a substantial systematic bias (*18*). In populations where accurate age information is known, weight-for-age must be interpreted cautiously because of the inability of this indicator on its own to distinguish between stunting and wasting.

Other issues not presented in Table 4, but which need to be considered with regard to whether weights and/or heights should be collected include the following: availability of accurate measuring equipment; training of health care workers to collect

Table 3: **Examples of differences in anthropometric status between various 18-month-old males of different weights and heights**

Example	Weight (kg)	Height (cm)	Anthropometry[a] WHZ	HAZ	WAZ	Description
1	10.7	88.5	–2.0	2.0	–0.7	Very tall
2	9.1	88.5	–3.7	2.0	–2.0	
3	10.2	85.4	–2.0	1.0	–1.1	Moderately tall
4	9.1	85.4	–3.2	1.0	–2.0	
5	9.1	79.4	–2.0	–1.0	–2.0	Moderately short
6	9.1	76.4	–1.3	–2.0	–2.0	Very short
7	8.5	76.4	–2.0	–2.0	–2.5	

[a] WHZ = weight-for-height *z*-score; HAZ = height-for-age *z*-score; WAZ = weight-for-age *z*-score.

Table 4: **Summary of information on anthropometric indices**

	Weight-for-height[a]	Height-for-age[a]	Weight-for-age[a]
Usefulness in populations where age is unknown or inaccurate	1	4	4
Usefulness in identifying wasted children[b]	1	4	3
Sensitivity to weight change over a short time period	1	4	2
Usefulness in identifying stunted children[b]	4	1	2

[a] 1 = excellent; 2 = good; 3 = moderate; 4 = poor.
[b] Depends to some extent on the prevalence of wasting and stunting in the population.

information accurately and to interpret the results of the measurements correctly; and the amount of time it takes to perform the measurements. Also, if one of the measurements is not collected, the costs of not identifying undernourished children or of incorrectly identifying adequately nourished children as undernourished need to be considered.

Scale of choice

The anthropometric indices can be described in terms of *z*-scores, percentiles, and percent-of-median. These measures are used to compare a child or a group of children with a reference population to determine "relative" status. The use of a single reference population provides information on relative status and should not be regarded as a "standard" or indicator of "desired" growth (*4*).

z-Scores

When the current International Growth Reference Curves were being developed, the curves were normalized. For example, with height-for-age, conceptually, at each age, there is a normal distribution of heights. This normalization is useful from a statistical point of view because precise individual values can be calculated and the distribution of anthropometric values from a population can be described in terms of means and standard deviations. Because the observed *z*-scores from a population are likely to be normally distributed, analytical procedures that assume normality, such as *t*-tests and regression methods, can be used. Recently, Mora has proposed a method based on the normality assumption for estimating the prevalence of low anthropometry that identifies the proportion of children who fall outside of the reference population distribution (*19*).

The proportion of children in a study population who fall above or below a cut-off point can easily be calculated and compared with the reference population. For example, in the reference population, the proportion of children <–2 SD is 2.3%, and this can then be compared with the prevalence of low anthropometry in the study population.

Percentiles

The calculation of percentiles is also based on the normalized curves. Percentiles from the reference population have a uniform distribution and may be useful since they are easy to interpret, but unlike *z*-scores they are usually not normally distributed (and therefore should not be described in terms of means and standard deviations) and are less useful in describing the extremes of the distribution.

Percent-of-median

Indices expressed as the percent-of-median can be a useful measure if the distribution around the median value is unknown or if the reference population distribution has not been normalized. In the growth reference populations used prior to the CDC/WHO growth reference, the curves were generally not normalized and the use of percent-of-median was therefore a convenient way of describing the distribution of children around the median. The percent-of-median is simpler to calculate than a *z*-score or percentile. Unfortunately, because the calculation of the percent-of-median ignores the distribution of the reference population around the median, the interpretation of a fixed percent-of-median value varies across age and height groups. In addition, the interpretation of an arbitrary cut-off value for low anthropometry expressed as a percent-of-median differs according to the index.

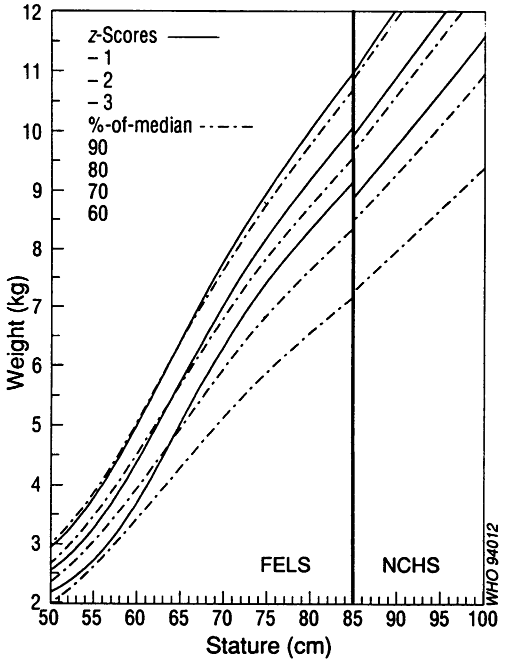
Considerations at the population level

In some instances there may be a need to rank populations according to the prevalence of low anthropometry in order to prioritize intervention activities. If age-specific or age-standardized prevalences are employed, the use of the different anthropometric scales should have little effect on the ranking. However, if age-specific or standardized information is not used, the scale of measurement could affect the ranking owing to the changing relation of the percent-of-median with the normalized scales (*z*-score and percentile) across the age and height groups.

Considerations at the individual level

In many situations, a single weight and height measurement is used to classify children as either "malnourished" or of "normal" nutritional status.

Fig. 1. **Comparison of selected z-score and percent-of-median curves, for males, for weight-for-height.**



(The use of single versus multiple longitudinal measurements to identify children who may be at greater health risk is discussed in more detail below). The use of z-scores versus percent-of-median can make a difference in the classification of individual children. For example, Fig. 1 compares three z-score levels (–1, –2, and –3 SD) with four percent-of-median levels (90, 80, 70, and 60 percent-of-median) for weight-for-height. In Fig. 1, 80 percent-of-median corresponds to approximately –1.8 SD at 49 cm, crosses the –2 SD curve at 65 cm, and at 84 cm corresponds to –2.8 SD. Therefore, in the classification of wasting, the use of –2 SD versus 80 percent-of-median cut-off points would identify different proportions of children at different heights, with the 80 percent-of-median cut-off identifying more children above 65 cm and fewer children below 65 cm.

Fig. 2 depicts similar relations with height-for-age, although the relation between z-scores and percent-of-medians is somewhat more stable. After approximately 9 years of age the difference between z-scores and percent of median begins to vary again (data not shown).

The relation between weight-for-age z-scores and percent-of-median curves is depicted in Fig. 3. Among children aged less than 10 months, the relation between the two scales is variable and relatively consistent for the 10–36-month age group. Above 9 years of age there is variability between the z-score and percent-of-median values, similar to that which occurs with height-for-age (data not shown).

As shown in Fig. 1–3, the relation between z-scores and percent-of-median values differs according to age and height. The interpretation of the z-scores is more straightforward, in that in the reference population there is a fixed percentage of children who fall below any z-score cut-off value. Because the percent-of-median ignores the distribution around the median, there is no fixed proportion of the reference population that would be expected to fall below a cut-off point for all ages and heights. The z-score and percent-of-median curve would be approximately the same only if the coefficient of variation were to remain constant throughout childhood. Because the coefficient of variation changes, especially in the first 2 years of life, the z-score and percent-of-median curves cannot provide the same information. Software can be used to compute z-scores, percentiles, and percent-of-median for each of the three indices with more detail than is possible using published tables (*20, 21*). A summary of the use of the different scales is shown in Table 5. In general, the z-score has properties that make it superior to the other two scales.

Fig. 2. **Comparison of selected z-score and percent-of-median curves, for males, for height-for-age.**

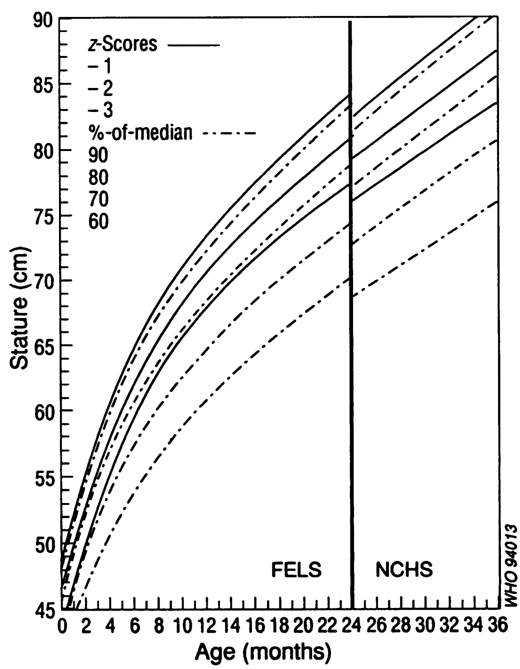
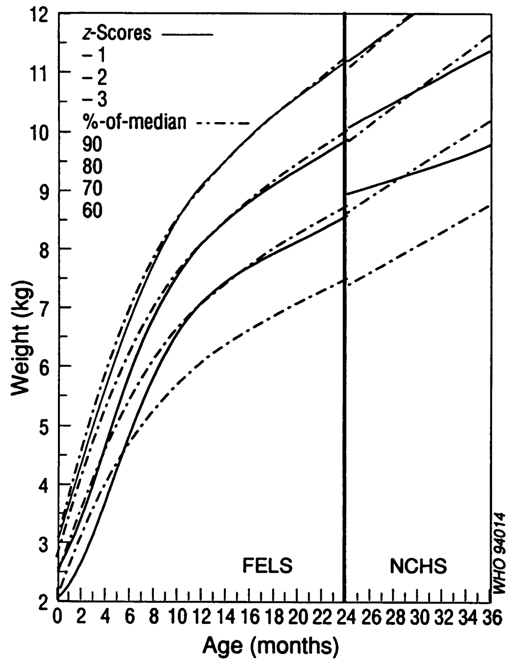


Fig. 3. **Comparison of selected z-score and percent-of-median curves, for males, for weight-for-age.**



Limitations of the current reference

The CDC/WHO reference curves are now widely used throughout the world and provide a useful reference against which a population's status may be evaluated. The reference has been described in detail elsewhere, and hence we highlight only its limitations here (*2, 23*). The rationale for the use of a reference has also been described previously (*4, 24*).

Table 5: **Summary of the use of anthropometric scales**

	z-Scores	Percentiles	Percent-of-median
Uses normalized curves	Yes	Yes	No
Interpretation of extreme values consistent across age and height groups[a]	Yes	Yes	No
Interpretation of cut-off value consistent across indices[b]	Yes	Yes	No
Ability to identify children with extreme values	Good	Poor	Good
Values from a study population are distributed normally	Yes	No	Yes[c]

[a] The physiological meaning or consequences of extreme values may differ across age and height groups.
[b] For example, 80 percent of median is about –4 SD for height-for-age, but about –2 SD for weight-for-age.
[c] May be skewed to upper values in weight-for-height and weight-for-age curves.

The reference curves were derived from two different populations. For children under 36 months of age, data collected by the FELS Research Institute were used, while for children aged 2–18 years data from a combination of U.S. representative cross-sectional health surveys performed by the National Center for Health Statistics (NCHS) were used. There are important differences between the two data sets and these are depicted in Table 6. Because the reference is derived from two distinct cohorts, the growth curves for each of the three indices are generally divided into two age categories: birth to 36 months and 2–18 years of age. Computer software packages that compute anthropometric values (such as Anthro, Epi Info, and EpiNut) generally use the FELS curves up to the second birthday (23.99 months of age) and then the NCHS curves for children aged ≥2 years (*20–22*).

There are critical differences between the FELS and NCHS curves in the age range (for height-for-age and weight-for-age) and height range (for weight-for-height) where the two curves overlap, causing a "disjunction" (*2*). There are two reasons for this. First, stature (linear growth) was measured differently in the two populations; recumbent lengths were collected for FELS data, while standing heights were measured for the NCHS data. Recumbent lengths are, on the average, greater than standing heights by approximately 0.5 cm. The effect of recumbent length versus standing height has a relatively small impact on anthropometric calculations.

The second and more important reason for the disjunctions arise because of differences in the reference population characteristics and study design (Table 6). The FELS data were collected from White, middle-class children followed longitudinally, while the NCHS data were derived from cross-sectional surveys representative of all U.S. children, including non-Whites and children from lower income households. This disjunction is due to differences between the median values of the two populations as well as differences in the distribution around the median. In general, the FELS children were taller and thinner than the NCHS children. The disjunction at the second birthday can be seen in Fig. 2 and 3,

Table 6: **Comparison of the data sets used in the CDC/WHO growth reference**

Data source	Representative?[a]	Age range (years)	Stature measurement	Study design
FELS	No	0.0–2.99	Recumbent	Longitudinal
NCHS	Yes	2.0–17.99	Standing	Cross-sectional

[a] Representative of the entire U.S. population.

and the disjunction at 85 cm, (the average height for children on their second birthday) in Fig. 1.

The growth reference curves also have age and height limitations for the three indices, and these are shown in Table 7. Note that there are no weight limitations. The most severe limitations occur with weight-for-height, where the minimum and maximum height limitations make it impossible to calculate weight-for-height for many children less than approximately 2 months of age (minimum height 49 cm) or above approximately 9 years for girls and 11 years of age for boys, respectively. The reason for this is that weight-for-height is not independent of age in the older children and that there is a greater variability in the weights and heights of children as they enter puberty.

Considerations at the population level

It has been suggested that anthropometric data for a population be presented by age groups (*4, 5, 25*). An important aspect of the presentation of the age-specific data is at the second birthday, where disjunction occurs. This is particularly critical when a comparison is made between two or more populations or between cross-sectional surveys within a geographical area, where apparent differences in anthropometric status between groups could be due entirely to differences in the age distributions of the groups. Since such differences between populations are often used for targeting programme resources, it is critical to identify correctly the groups at the greatest physiological risk.

In evaluating the age-specific prevalence of low anthropometry surveys from around the world, the improvement generally observed in height-for-age, weight-for-height, and weight-for-age in comparisons of children aged <2 years with those aged ≥2 years can be attributed, to a great extent, to the disjunction of the growth reference curves. It should be emphasized that important biological, sociological, and behavioural changes occur around a child's second birthday, and an improvement in anthropometric status may reflect a true change in health status. Nevertheless, within a population we cannot clearly discriminate between what portion of this change is attributable to the disjunction in the reference population or is the result of physiological change.

Table 7: **Age and height limitations for the CDC/WHO international growth reference curves**[a]

		Age limitation (years)		Height limitation (cm)	
Index	Sex	Minimum	Maximum	Minimum	Maximum
Weight-for-height	Males	Birth	11.49	49	145
	Females	Birth	9.99	49	137
Weight-for-age	Both	Birth	17.99	None	None
Weight-for-age	Both	Birth	17.99	None	None

[a] There are no weight limitations.

Considerations at the individual level

The impact of the disjunction in the growth curves has a similar effect on monitoring the growth of individuals as that of populations. The data in Table 8 illustrate the effects of the FELS and NCHS curves on individual growth assessment. In Table 8, example 1 displays data for a short, thin male child just before his second birthday; in example 2, the same child's status is assessed on his second birthday. Note the changes in the child's *z*-score values with a change in age of less than one day, with the height-for-age *z*-score and the weight-for-height *z*-score improving, and the weight-for-age *z*-score getting worse.

Example 3 shows the results of correcting the recumbent height by subtracting 0.5 cm to estimate the standing height. While this has no effect on the weight-for-age *z*-score, it slightly reduces the difference in the height-for-age *z*-scores between examples 1 and 3 but slightly increases the difference between the weight-for-height *z*-scores. Examples 4–6 in Table 8 deal with a child of average height and weight, while examples 7–9 are for a tall, heavy child. In general, the disjunction of the growth reference curves tends to have a more pronounced effect on individuals at the extremes of the distributions and a lesser effect on those near the median, primarily because of the differences in the widths of the distributions for the FELS and NCHS populations. In addition, the correction of recumbent lengths to standing heights by subtracting 0.5 cm makes little difference at the level of the individual.

When an individual child's growth is tracked over time, an effect similar to that observed at the population level is noted. When children reach 2 years of age, dramatic changes may occur in their height-for-age, weight-for-height, and weight-for-age indices, due primarily to the disjunction of the two reference curves.

Single versus multiple measurements

Many different study designs have been employed to assess the nutritional status of populations and individuals. In this section we discuss the implications of using a single cross-sectional measurement to classify populations or children with low anthropometric levels compared with the use of multiple (longitudi-

Table 8: **Examples of differences between the FELS and NCHS curves, based on a male child just before and on his second birthday**

	Age (months)	Weight (kg)	Stature[a] (cm)	Curve	Anthropometry[b] WHZ	HAZ	WAZ
Short, thin child							
1	23.99	8.8	79.2 (rec.)	FELS	−2.3	−2.5	−2.9
2	24.00	8.8	79.2 (rec.)	NCHS	−2.0	−2.0	−3.2
3[c]	24.00	8.8	78.7 (sta.)	NCHS	−1.9	−2.2	−3.2
Average height and weight child							
4	23.99	12.4	85.6 (rec.)	FELS	0.3	−0.6	−0.1
5	24.00	12.4	85.6 (rec.)	NCHS	0.1	0.0	0.0
6[c]	24.00	12.4	85.1 (sta.)	NCHS	0.2	−0.2	0.0
Tall, heavy child							
7	23.99	16.7	92.0 (rec.)	FELS	3.0	1.3	3.2
8	24.00	16.7	92.0 (rec.)	NCHS	2.0	2.0	2.6
9[c]	24.00	16.7	91.5 (sta.)	NCHS	2.1	1.9	2.6

[a] rec. = recumbent; sta. = standing.
[b] WHZ = weight-for-height *z*-score; HAZ = height-for-age *z*-score; WAZ = weight-for-age *z*-score.
[c] 0.5 cm subtracted from prior example to estimate standing height.

nal) measures. Additional information on the purpose and use of single versus multiple anthropometric measurements in different settings has appeared previously (*5*).

Considerations at the population level

Periodic representative cross-sectional surveys within a population are useful for describing changes in anthropometric status over time. This is the commonest mode of providing information on the overall growth of children. An increase in the prevalence of low anthropometry (or negative shift in the distribution of anthropometric values) over time might be an indication of nutritional or other problems and would merit further investigation. A decrease in the prevalence might reflect an improvement in conditions believed to have an impact on growth and health, including education, household purchasing power, water quality, sanitation, infectious disease burden, and nutritional intake.

The problem presented by the disjunction in the growth reference is also important in the longitudinal follow-up of populations, especially in situations where one group is receiving an intervention and the other serves as a comparison group. Unless the age distributions between the two populations are very similar, comparisons should be performed on an age-specific or age-standardized basis.

Considerations at the individual level

Ideally, individuals should periodically be weighed and have their height measured so that the growth velocity, a more sensitive indicator of health than weight or height attained, can be assessed. A marked decline in an individual's anthropometric index over time, assuming that the measurements were made accurately, could be an early indicator of an illness or nutritional deficiency that may result in serious health outcomes. From a clinical viewpoint, a child with a dramatic decline in weight-for-height status (but still >−2 SD) would probably be in greater need of assessment than one who has consistently tracked just slightly below −2 SD. However, there is no generally accepted definition of "growth faltering", and further research is necessary to define the health risks associated with such faltering as well as whether these risks are affected by others factors, such as age and initial anthropometric status.

When an individual is followed up over time, it is important to recognize the disjunction of the FELS and NCHS curves, as shown in Fig. 1–3.

In some situations, only a single set of measurements are available to classify children as having low anthropometry. While the use of a cut-off point for this purpose is somewhat arbitrary (e.g., <−2 SD of the median of the reference population), it may be necessary in certain circumstances. In general, children with low anthropometry have, on the average, a higher risk of adverse outcomes, with some studies demonstrating a threshold effect with the risk of mortality increasing (*26*).

Conclusions and recommendations

The tracking of an individual child's weight-for-height *z*-scores on growth curves is a sensitive indicator of short-term nutritional status. Children with growth faltering can be assessed further to determine its cause, such as whether it is due to infectious diseases or inadequate nutrient intake. At the population level the weight-for-height status is useful for assessing short-term nutritional problems.

If the age is accurately known, an individual child's height-for-age *z*-score should be tracked to assess linear growth. In developing countries, treatment for stunting may not be readily apparent. If the child has also a low weight-for-height or his/her weight-for-height is faltering, the child should be assessed as described above. If the child has normal weight-for-height but low height-for-age, the most appropriate treatment at the individual level is not obvious. If one of the causes of stunting in a population is found to be due, in part, to micronutrient deficiencies, inadequate protein intake, intensity of parasite infection (*27*), or other cause, this information could be used to prevent further stunting of individual children, and even to reverse the process to some extent. At the population level, a high prevalence of stunting should result in the initiation of activities directed towards factors associated with stunting within the population, although unless there is an improvement in the socioeconomic status of the population, there may be little impact on the overall prevalence of stunting.

The use of weight-for-age alone for tracking individual children has been an important tool for growth monitoring, but should be used only in populations where accurate age information is available. (Once a child's date of birth is estimated and used consistently, growth charts for weight-for-age and height-for-age may be useful for tracking a child's anthropometric status but not for comparison with a cut-off value.) Without a height measurement it is difficult to determine whether growth faltering is a result of inadequate weight gain (or loss of weight), an inadequate growth in height, or both (*5*). However, severe faltering over a short period is most probably due to inadequate weight gain or weight loss. It would be difficult to attribute a mild growth faltering over a longer time period to either inadequate weight gain or inadequate height gain. At the population level, a high prevalence of underweight in the absence of height data does not fully describe the type of nutritional problem(s) the population may be experiencing, whether wasting or stunting. In areas where weight-for-age has been the traditional index used for growth monitoring, and where it may not be practical to collect the lengths or heights of all children, a two-step evaluation may be useful. In this situation, children are monitored using weight-for-age growth charts; those found to be faltering in growth or below a selected cut-off value would have their length or height measured to assess their weight-for-height and height-for-age. The specific weight-for-age cut-off depends upon the following: the index of primary interest (weight-for-height versus height-for-age or both); the prevalence of low weight-for-height or low height-for-age in the population; and the desired levels of sensitivity and specificity.

Many anthropometric classification schemes attach a label for those with low anthropometry, such as "mild", "moderate", or "severe" malnutrition; "wasted" or "stunted". Such labels may be misleading. Not all children who fall below a cut-off are malnourished, and not all children who are above the cut-off are well nourished (*28*). The use of a cut-off should be thought of as a screening device to identify children who are *more likely* to be undernourished. Further evaluation is necessary to distinguish children who have low anthropometry but are healthy from those who are undernourished due to lack of proper nutrition and/or organic conditions.

When the anthropometric status of a population is described, the results should always be given by age group (if the age information is accurate) (*5, 25*). For purposes of comparing the prevalence of low anthropometry data between different geographical areas, it is sometimes preferable to have a summary measure. One way to address this issue would be to standardize the age-specific information using a standard age distribution, which would permit reasonable comparisons to be made between populations.

If age is not known, the presentation of weight-for-height data should be provided by dividing the population into at least two height groups: <85 cm and ≥85 cm (85 cm is the average height for children aged 24 months). In addition, if age is unknown, the FELS curves are used for children <85 cm and the NCHS data for those ≥85 cm.

Anthropometry has been an extremely useful tool for determining the nutritional status of both individuals and populations. This article has summarized some of the important issues to consider in determining which index or indices to use (weight-for-height versus height-for-age versus weight-for-age), which scale to use (*z*-scores versus percentiles versus percent-of-median), and some of the limitations of the growth curves that affect the interpretation of anthropometry.

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Résumé

Questions soulevées par l'utilisation de l'anthropométrie pour évaluer l'état nutritionnel

L'utilisation et l'interprétation des méthodes anthropométriques soulèvent quatre questions au niveau de la population et de l'individu. La première porte sur le choix du ou des indices: poids/taille, taille/âge ou poids/âge. Ce choix dépend de nombreux facteurs et aucun indice ne convient parfaitement à toutes les situations. Les deux indicateurs anthropométriques préférés pour évaluer l'état nutritionnel sont le rapport poids/taille et le rapport taille/âge, car ils permettent de distinguer deux processus physiologiques et biologiques différents. Le rapport poids/âge est essentiellement un indice composite résultant de la combinaison des deux précédents, et il ne permet pas de distinguer les enfants grands et maigres de ceux qui sont petits, mais dont le poids est normal. Des critères sont proposés pour évaluer la gravité des carences mesurées par les indices anthropométriques au sein d'une population.

La seconde question concerne le choix de l'échelle utilisée pour l'indice: valeurs Z (ou écarts-types), centiles ou pourcentages par rapport à la médiane. La première est supérieure aux deux autres pour plusieurs raisons: elle repose sur des courbes normalisées; les valeurs extrêmes sont interprétées de la même façon, quel que soit le groupe d'âge ou de taille; l'interprétation des valeurs seuils (par exemple <-2 ET) est également la même pour tous les indices; cette échelle est utile pour identifier les enfants présentant des valeurs extrêmes; dans la plupart des populations étudiées, les valeurs présentent une distribution normale, ce qui permet d'utiliser des méthodes statistiques fondées sur cette hypothèse.

La troisième question concerne les limites du système actuel de référence pour la croissance. La principale de ces limites est due au décalage entre les courbes de croissance à l'âge de deux ans, du fait de l'utilisation de deux populations de référence différentes. Il est important de reconnaître l'existence de ce décalage pour pouvoir interpréter correctement les indices anthropométriques des enfants appartenant à ce groupe d'âge. D'autres limites s'appliquent également à l'âge et à la taille pour le calcul du rapport poids/taille.

Enfin, l'article passe en revue certaines questions concernant les avantages comparés des données anthropométriques transversales (mesure unique) et longitudinales (mesures multiples). Pour rendre compte des caractéristiques anthropométriques d'une population, il convient de présenter les résultats par groupe d'âge lorsque les données relatives à l'âge sont fiables. Si tel n'est pas le cas, la population doit être divisée en au moins deux groupes en fonction de la taille (<85 cm et ≥85 cm), pour la présentation du rapport poids/taille, 85 cm étant la taille moyenne des enfants âgés de 24 mois dans la population de référence.

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